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ABSTRACT

This booklet, one of a series of 17 developed at Prince George's Community College, Largo, Maryland, provides an individualized, self-paced undergraduate organic chemistry instruction module designed to augment any course in organic chemistry but particularly those taught using the text "Organic Chemistry" by Morrison and Boyd. The entire series of modules covers the first 13 chapters of the Morrison-Boyd text in great detail. Each module has been provided with from one to three audiotapes, available from Prince George's Community College, to provide students additional explanations of particular concepts. Each module includes a self-evaluation exercise, a reference guide, worksheets to be completed with the audiotapes, answer sheets for the worksheets, a progress evaluation, an answer sheet for the progress evaluation, an answer sheet for the self-evaluation exercise, an introduction to the topic covered by the module, and student performance objectives for the module. The topic of this module is the history of optical activity and enanticmerism. (SL)

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ORGANIC CHEMISTRY

V. Zdravkovich

6

Self
Instructional
Package

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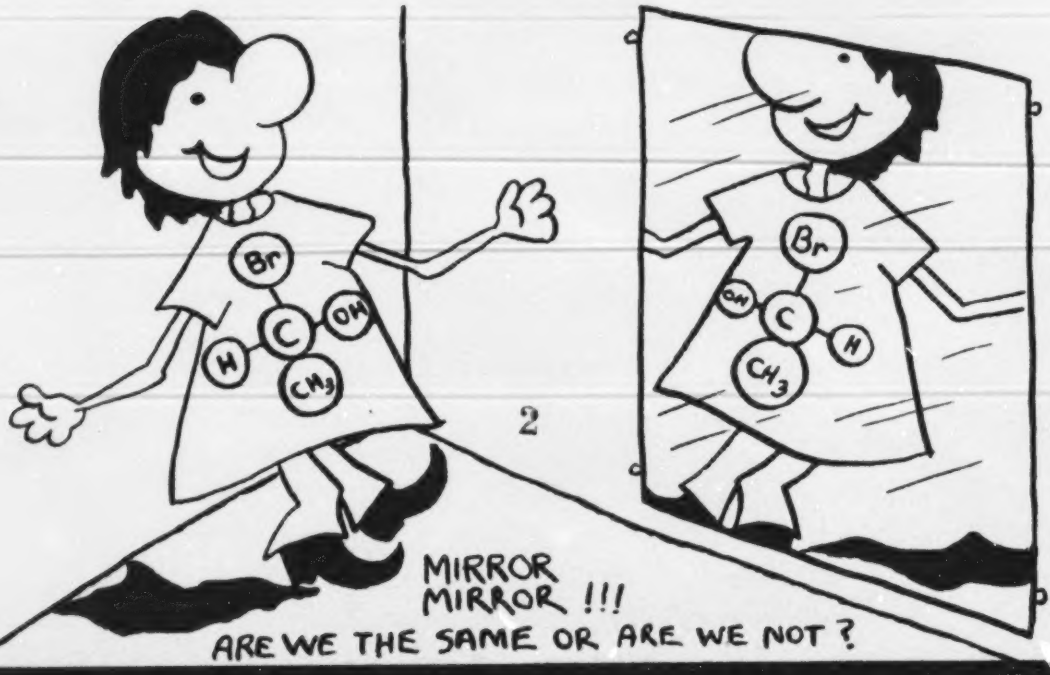
STEREOCHEMISTRY 1



SE 021 577

Self Instructional Sequence in

ORGANIC CHEMISTRY

"Copr.," V. Zdravkovich 1976

Men are called fools in one age for what they were averring in the age before.

---Henry Ward Beecher

History of Optical Activity and Enantiomerism

The history of optical activity and stereoisomerism is long, involved and most interesting. You can learn about this concept knowing nothing of its historical background. However, it would be analogous to moving into a house without furniture. You can live in it but you would miss all the frills that one learns to enjoy and need. Hence, your appreciation of the subject would be incomplete.

The historical events which led to the discovery of the concepts discussed in this tape and which will help to elucidate what follows are enumerated in chronological order below:

Optical Activity -

1669 - Danish scientist Erasmus Bartholimus found that a single ray of ordinary light can be divided into two rays by a properly oriented crystal made of calcite or Iceland spar.

1811 - French physicist Dominique Arago discovered that a quartz plate cut in a certain manner causes rotation of the plane polarized light.

1815 - French physicist Jean Baptiste Biot added a new dimension to Arago's discovery. He discovered that plates of the same thickness made from two kinds of quartz rotate plane polarized light the same amount but in opposite directions.

1828 - Scottish physicist William Nicol invented a prism called a Nicol prism used to produce a plane polarized light.

Enantiomerism -

1769 - Scheele isolated tartaric acid for the first time.

1819 - Jean Baptiste Biot determined that tartaric acid is optically active - dextrorotatory.

1828 - Kestner isolated from grapes an acid that had the same molecular formula, the same structure and the same physical properties as tartaric acid, but was optically inactive itself. It was later named RACEMIC acid by Gay Lussac (Racemes in Latin means grapes)

1830 - Berzelius named these two compounds, namely tartaric acid and racemic acid, ISOMERS. The word isomer was finally introduced to the scientific world.

History of Optical Activity and Enantiomerism (continued)

1848 - Jean Louis Pasteur separated the salt crystals of the optically inactive racemic acid into two types of crystals which were mirror images relative to each other. Each group of crystals was optically active.

1874 - Van't Hoff and Le Bell published their famous paper about the tetrahedral carbon atom which established the basis for the concept of mirror image isomerism of organic molecules. It opened the doors to the exciting field of stereochemistry.

(You can see the reaction of the chemical world to this paper in the Introduction in Self Instructional Package No. 2)

Self Instructional Package No. 6
Form A - List of Objectives

STEREOISOMERS I

Definitions -

The student will be able to define or describe and illustrate with appropriate examples (where applicable) the following terms: stereochemistry, stereoisomers, isomer number, plane-polarized light, optically active substance, optically inactive substance, polarimeter, dextrorotatory, levorotatory specific rotation, enantiomers, chiral center, racemic mixture or racemic modification, configuration, R and S configuration, diastereoisomers, meso compound, conformers, resolution.

Problems -

The student will be able to identify the chiral centers in a given molecule.

For a given compound, the studentwill be able to identify all the teoretically possible stereoisomers and label them correctly as enantiomers, diastereoisomers or meso compounds and as optically active or inactive.

The student will be able to identify the chiral molecules in a given set of different compounds.

The student will be able to assign the R or S configuration to a given chiral molecule.

The student will be able to draw the correct configuration from the given R or S structural formula.

The student will be able to identify the given pairs of molecules an enantiomers, diastereoisomers, meso compounds or racemic mixture.

Self Instructional Package No. 6
Form B - Self Evaluation Exercise

STEREOISOMERS I

Identify the statements below as True or False by placing a capital T or F in the space to the left.

1. _____ The correct definition for enantiomers is: enantiomers are mirror image isomers.

2. _____ Enantiomers have different physical properties.

3. _____ Diastereoisomers are nonsuperimposable mirror image isomers.

4. _____ Meso compounds are optically inactive.

5. _____ Racemic mixture is optically inactive.

6. _____ An enantiomer is optically active.

7. _____ All diastereoisomers are optically active.

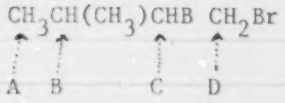
8. _____ Meso compounds contain no chiral centers.

9. _____ Diastereoisomers have different physical properties.

10. _____ Racemic mixture can be resolved into two enantiomers.

Blacken out the correct answer or answers in the following questions:

11. The chiral center in the compound below is:



a) A
b) B
c) C
d) D

12. Correct statements about 2-bromo-3-methyl butane are:

a) it contains two chiral centers.

b) it can exist as a pair of optically active enantiomers.

c) it is a meso compound.

d) it can exist in form of an optically inactive racemic mixture.

13. Correct statements about 3,4-dibromo hexane are:

a) it contains two chiral centers.

b) it can exist as a pair of optically active enantiomers.

c) it can exist as a meso compound.

d) there are four stereoisomers that can be separated and identified of 3,4-dibromo hexane.

14. Correct statements about 2,3-dibromo pentane are:

a) it contains two chiral centers.

b) it can exist as a pair of optically inactive enantiomers.

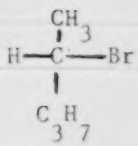
c) it can exist as a meso compound.

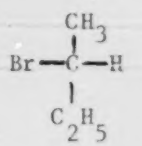
d) there are four stereoisomers that can be separated and identified of 2,3-dibromo pentane.

Identify the pairs of compounds in the next six questions as: a) enantiomers, b) diastereoisomers, c) meso compounds, d) none of the above.

15.

16.





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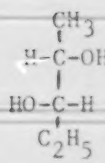

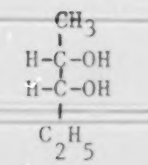

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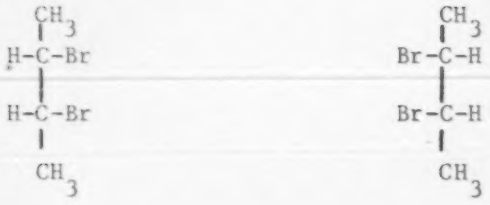
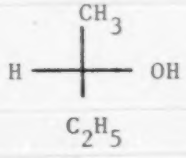


19.

20.

Identify the compounds in the next five questions as a) optically active, b) optically inactive, c) meso compound, d) enantiomer.

21.



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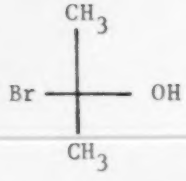

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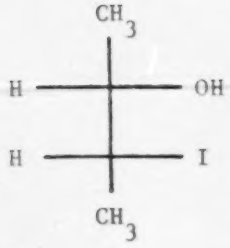

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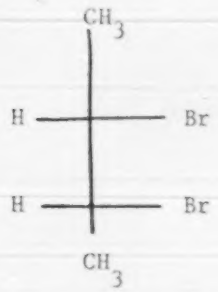

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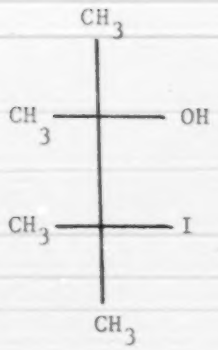


26. A dextrorotatory substance has the following characteristic properties:

a) It has an R configuration.

b) It turns the plane-polarized light to the right.

c) It has an S configuration.

d) It should be labeled with a prefix (+)

27. The correct statements about an unknown substance that shows an angle of rotation $\alpha = +5.6°$ when placed in a polarimeter are:

a) This substance is made up of chiral molecules.

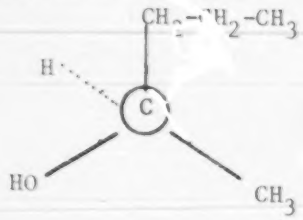
b) This substance may be the positive enantiomer.

c) This substance may be the racemic mixture.

d) This substance may be a mixture containing an excess of the dextrorotatory enantiomer.

SIP No. 6
Form B - Self Evaluation Exercise

28. The correct statements about the configuration below are:



a) It is an R- configuration.

b) It is an S- configuration.

c) It is a dextrorotatory substance.

d) It is a levoratatory substance.

Self Instructional Package No. 6
Form C - Reference Guide

STEREOISOMERS I

The Reference Guide should be used in conjunction with Form B or the Self Evaluation Exercise. The references given are geared specifically toward the questions on Form B.

Questions No. 1, 6	Chapter 4, Sections 6, 7, 8
Question No. 2, 6	Chapter 4, Section 11
Questions No. 3, 7, 9	Chapter 4, Section 17
Questions No. 4, 8, 18, 24	Chapter 4, Section 18
Question No. 5, 10	Chapter 4, Section 12
Question No. 11	Chapter 4, Section 10
Questions No. 12, 15, 16, 21, 22, 25	Chapter 4, Sections 9, 10
Questions No. 13, 14, 17, 19, 20, 23	Chapter 4, Sections 17, 18
Question No. 26	Chapter 4, Section 4
Question No. 27	Chapter 4, Section 13

For Questions 1, 2, 5, 6, 10, 11, 12, 15, 16, 21, 22, 25, 26, 27, additional explanations and examples can be found in Tape 1 - Optical Activity, Enantiomerism, R, S configurations with the accompanying work sheet and answer sheet.

For Questions 3, 4, 7, 8, 9, 13, 14, 17, 18, 19, 20, 23, 24, additional explanations and examples can be found in Tape 2 - Diastereoisomerism with the accompanying work sheet and answer sheet.

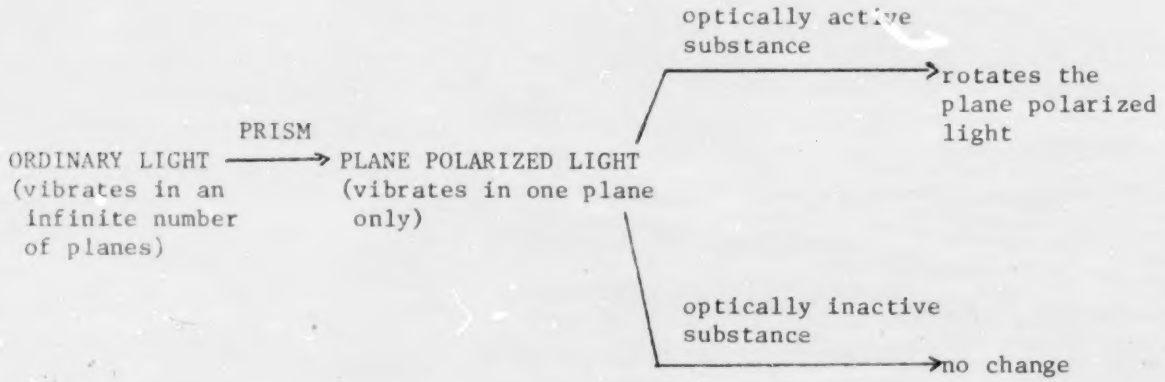
I am not ashamed to confess that I am ignorant of what I do not know.
---Cicero

STEREOISOMERISM I

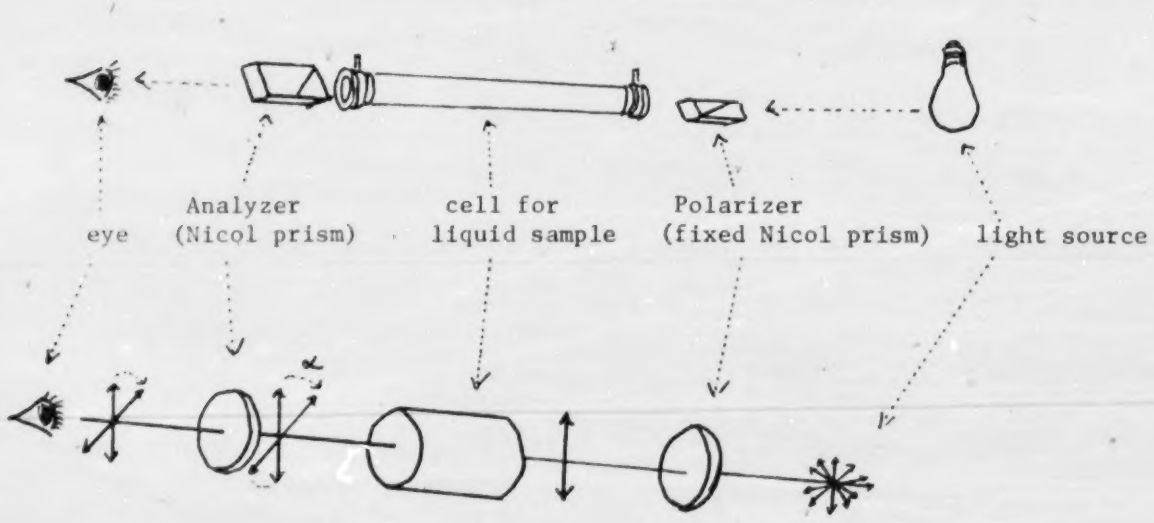
Optical Activity, Enanteomerism, R, S Configurations

Example No. 1 - optically active substances

An optically active substance is a substance that rotates the plane polarized light.


optically active substance
rotates the plane polarized light
PRISM
ORDINARY LIGHT (vibrates in an infinite number of planes)
PLANE POLARIZED LIGHT (vibrates in one plane only)
optically inactive substance
no change

Example No. 2 - Polarimeter



SIP No. 6
Tape I - Work Sheet

Example No. 3

optically active substance (+) or (-)

→ DEXTROROTATORY or (+) - it rotates the plane polarized light to the right

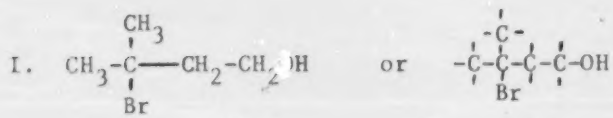
→ LEVOROTATORY or (-) - it rotates the plane polarized light to the left

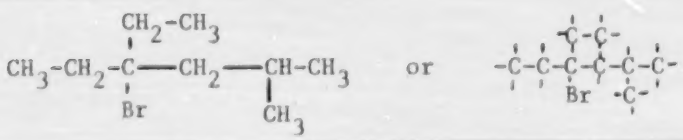
Example No. 4 - van't Hoff and Le Bell, 1874

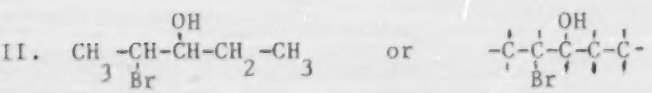
1. For any atom A only one substance of formula CH_3A has ever been found.
2. For any atoms A and B only one substance of formula CH_2AB has ever been found.
3. For any different atom A, B and D two nonsuperimposable mirror image isomers of the formula CHABD were found.

van't Hoff and Le Bell in 1874: only if the four atoms or four groups attached to the carbon atom are directed to the corners of a regular tetrahedron, statements 1, 2 and 3 are fully accounted for.

Example No. 5

I. 

II. 

III. 

SIP No. 6
Tape I - Work Sheet

Assignment No. 1

Identify all chiral centers in each of the compounds below:

a) $CH_3\ CH_2\ CHBr\ CH_2OH$

b) $CH_3\ \underset{\displaystyle CH_3}{CH}\!-\!CH\!-\!CH_2\!-\!CH_2Br$ (the CH_3 is a branch on the CH)

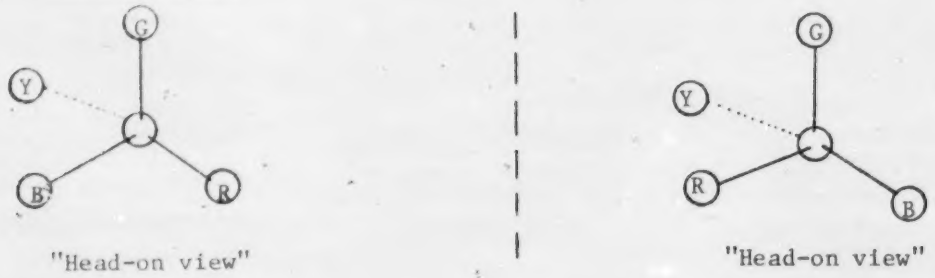
c) $CH_3\!-\!\underset{\displaystyle CH_3}{CH}\!-\!\underset{\displaystyle C_2H_5}{CH}\!-\!CH_2\!-\!CH_3$

d) $CH_3\!-\!CH_2\!-\!\underset{\displaystyle OH}{CH}\!-\!\underset{\displaystyle CH_3}{CH}\!-\!CH_2\!-\!CH_3$

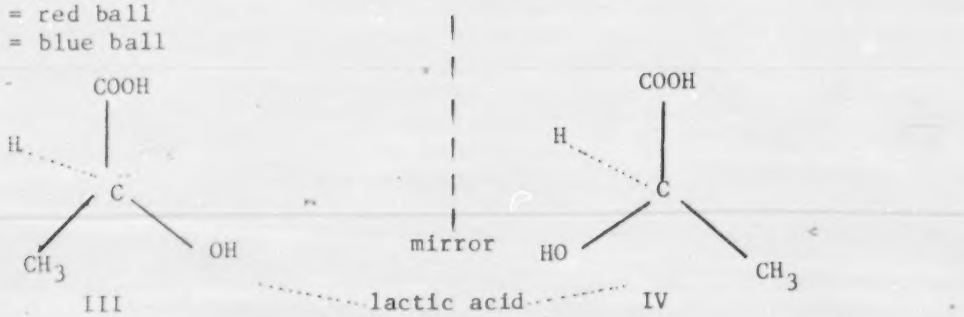
e) $CH_3\!-\!\underset{\displaystyle OH}{CH}\!-\!\underset{\displaystyle OH}{CH}\!-\!CH_2OH$

f) $CH_3\!-\!\underset{\displaystyle OH}{\overset{\displaystyle CH_3}{C}}\!-\!\underset{\displaystyle Br}{CH}\!-\!CH_3$

Example No. 6



G = green ball
Y = yellow ball
R = red ball
B = blue ball



ENANTIOMERS are nonsuperimposable mirror image isomers (such as I and II and III and IV)

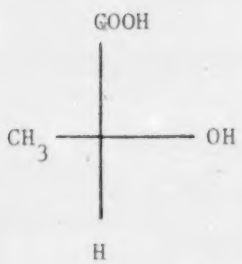
SIP No. 6
Tape I - Work Sheet

Example No. 7

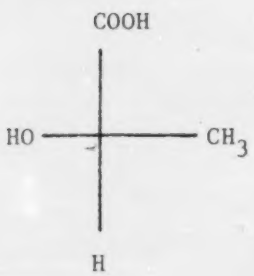
In the diagrams below the horizontal lines represent bonds coming toward us out of the plane of the paper; the vertical lines represent bonds going away from us behind the plane of the paper.

I

II



III

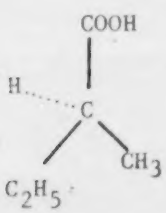


IV

Assignment No. 2

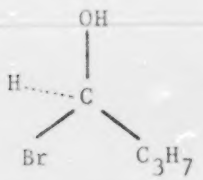
Complete the diagrams to the right that will correctly represent the compounds on the left.

a)

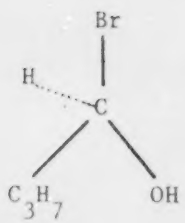


Assignment No. 2 (continued)

b)



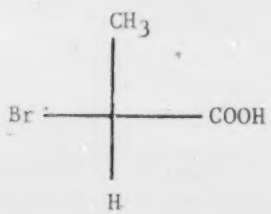
c)

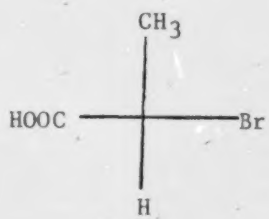


Assignment No. 3

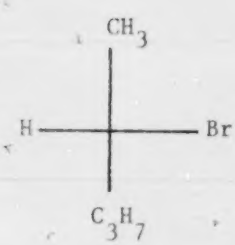
Identify each pair of compounds below as superimposable or nonsuperimposable.

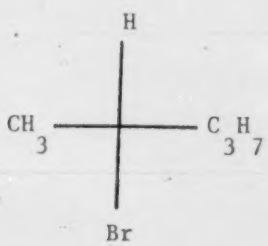
a)





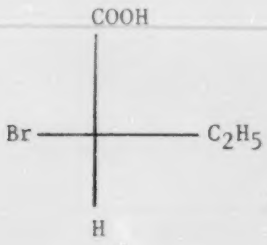
b)

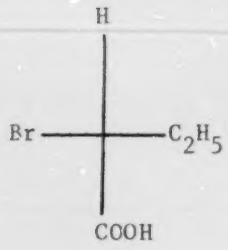




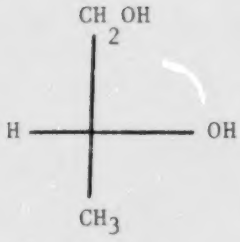
Assignment No. 3 (continued)

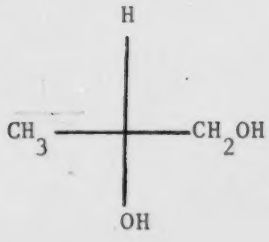
c)





d)

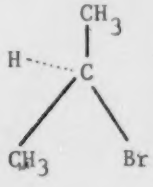


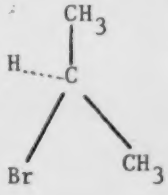


Assignment No. 4

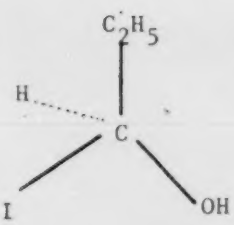
Identify each pair of the compounds below as: superimposable or non-superimposable; optically active or inactive (when separated); enantiomers; different or identical.

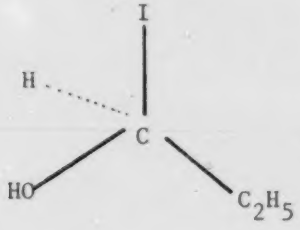
a)





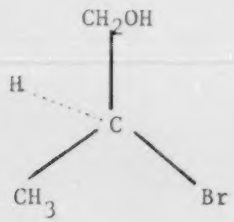
b)

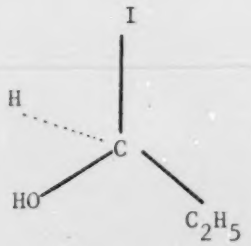




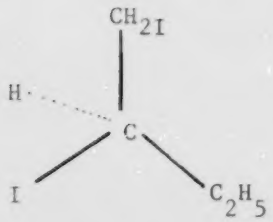
Assignment No. 4 (continued)

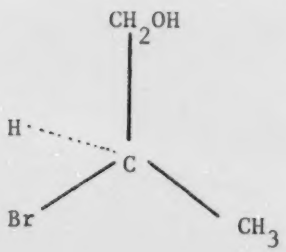
c)





d)





Assignment No. 5

Draw the stereochemical formulas for both enantiomers for each of the compounds below:

a) 2-bromobutane

b) 2-hexanol (CH_3 CH OH CH_2 CH_2 CH_2 CH_3)

c) 1-bromo-2-methyl butane

SIP No. 6
Tape I - Work Sheet

Assignment No. 6

Compare the dextrorotatory and the levorotatory forms of 2-bromo butane with respect to:

a) density

b) boiling point

c) melting point

d) rate of reaction with bromine in light

e) rate of reaction with magnesium in ether

f) index of refraction

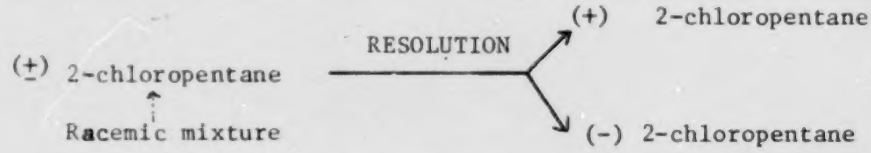
g) specific rotation

h) solubility in chloroform

Example No. 8

Racemic mixture is a mixture consisting of equal amounts of the two enantiomers.

Resolution is the separation of the racemic mixture into the enantiomers.



Assignment No. 7

Identify the statements below as True or False.

a) _____ a given mixture of enantiomers is optically inactive.

b) _____ a mixture containing an excess of the levorotatory compound will be optically active.

c) _____ from the given configurations of the two enantiomers one can identify the dextrorotatory and the levorotatory one.

d) _____ Racemic mixture is a mixture of two enantiomers.

SIP No. 6
Tape I - Work Sheet

Example No. 9 - Determination of the configuration

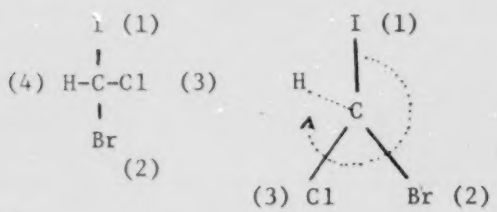
Configuration is the arrangement of atoms that characterizes a particular stereoisomer.

Step 1 - A sequence of priority is assigned to the four atoms or groups attached to the chiral center by employing the set of sequence rules.

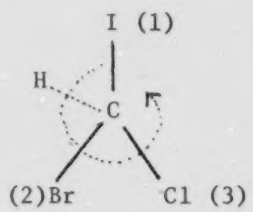
Step 2 - The molecule is visualized oriented so that the atom or the group with lowest priority points away from the viewer or is in the back. The arrangement of the remaining three groups is then observed.

Example No. 10 - Sequence Rules

Rule No. 1 - Higher atomic number precedes the lower atomic number.

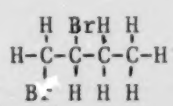


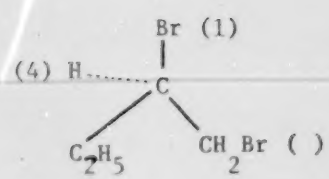
R Configuration

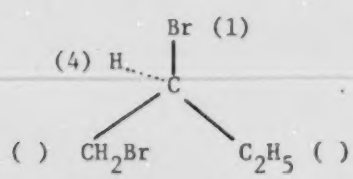


S Configuration

Rule No. 2 - If the priority sequence cannot be determined on the basis of the atoms directly bonded to the carbon atom, it will be determined by the next atoms in the group and so on, working outward from the chiral center (this is known as the technique of "outward exploration".







_____ Configuration

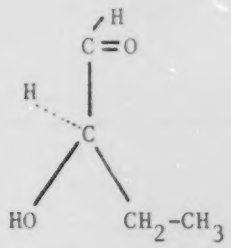
_____ Configuration

SIP No. 6
Tape I - Work Sheet

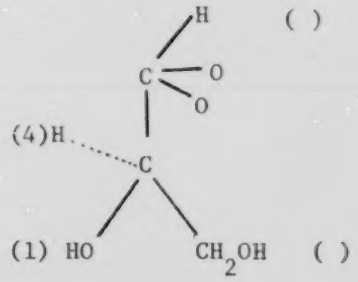
Example No. 10 - Sequence Rules (continued)

Rule No. 3 - A double or a triple bonded atom is equivalent to two or three of the same atom single bonded.

A.



same as:

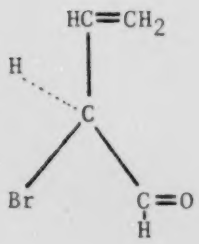


( )

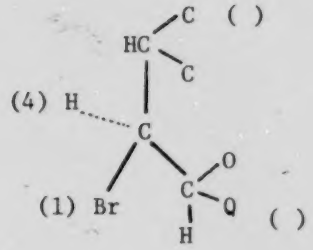
( )

_____ Configuration

B.



same as:



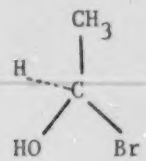
( )

_____ Configuration

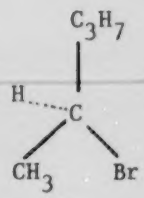
Assignment No. 8

Identify the priority sequence and assign the correct R or S configuration to the following compounds:

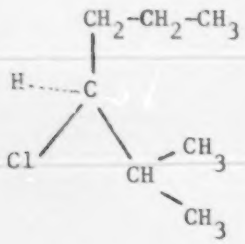
a)



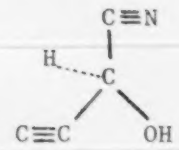
b)



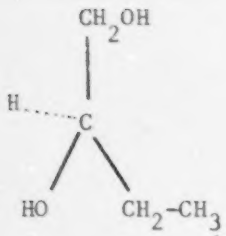
c)



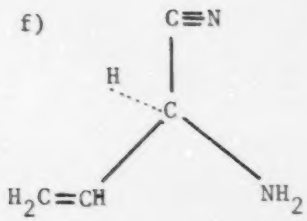
e)



d)



f)



Assignment No. 9

Draw the R and S configuration for the following compounds:

a) 2-bromobutane

b) 3-hexanol ($CH_3\ CH_2\ CHOH\ CH_2\ CH_2\ CH_3$)

c) 3-methyl-2-bromo butane

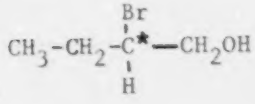
d) 1,3-dibromo pentane

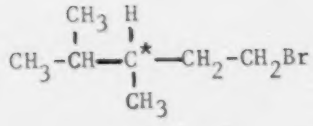
Self Instructional Package No. 6
Tape 1 - Answer Sheet

Stereoisomerism I

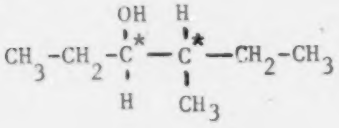
Optical activity, Enantiomerism R, S Configurations

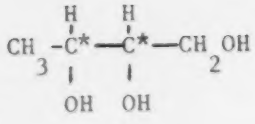
Assignment No. 1

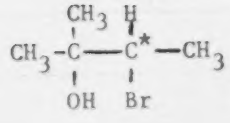
a)  (one chiral center)

b)  (one chiral center)

c) No chiral centers

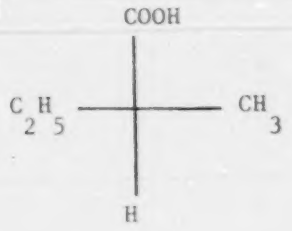
d)  (two chiral centers)

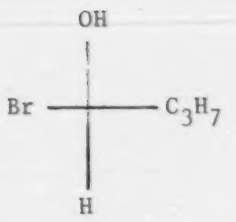
e)  (two chiral centers)

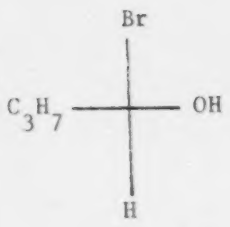
f)  (one chiral center)

SIP No. 6
Tape I - Answer Sheet

Assignment No. 2

a) 

b) 

c) 

Assignment No. 3

a) nonsuperimposable

b) nonsuperimposable

c) nonsuperimposable

d) superimposable

Assignment No. 4

a) identical, superimposable, optically inactive

b) superimposable, identical, optically active

c) nonsuperimposable, enantiomers, optically active

d) nonsuperimposable, different, optically active

SIP No. 6
Tape I - Answer Sheet

Assignment No. 5

a)

b)

c)

Assignment No. 6

a) identical
b) identical
c) identical
d) identical
e) identical
f) identical
g) identical
h) identical

SIP No. 6
Tape I - Answer Sheet

Assignment No. 7

a) F

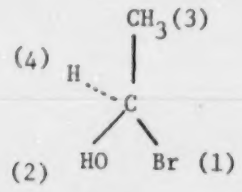
b) T

c) F

d) F (incomplete statement)

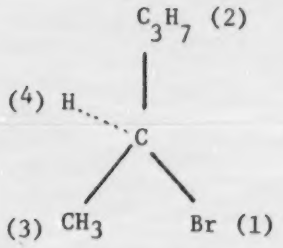
Assignment No. 8

a)



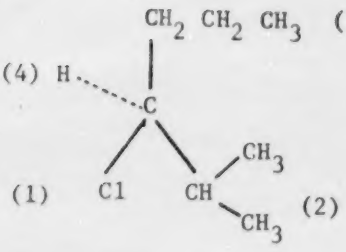
R-

b)



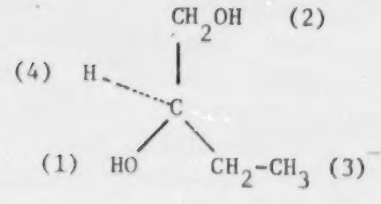
S-

c)



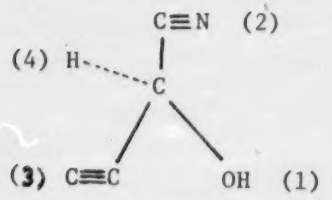
S-

d)

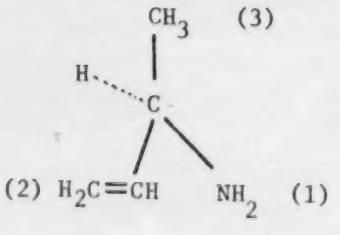


R-

e)



S-

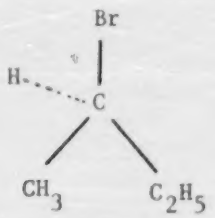


R-

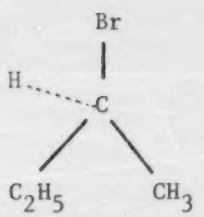
SIP No. 6
Tape I - Answer Sheet

Assignment No. 9

a)

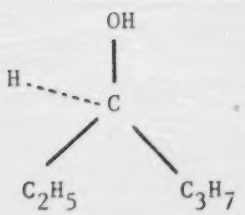


R-

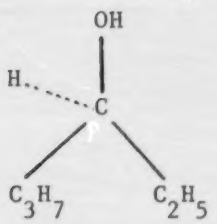


S-

b)

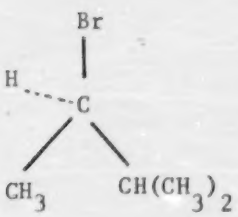


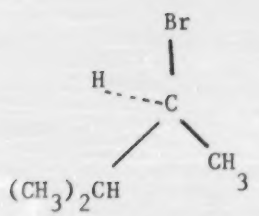
R-



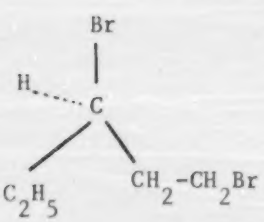
S-

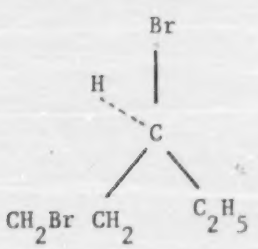
c)





d)





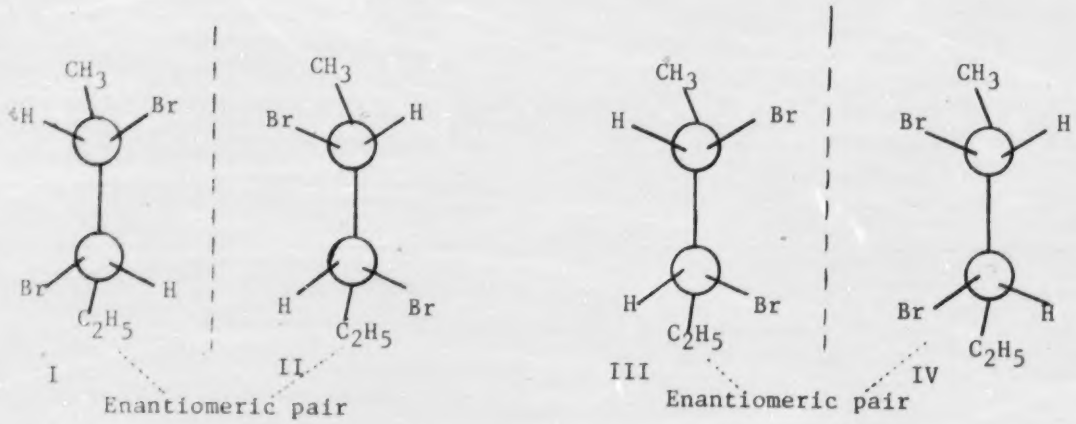
It is better, of course, to know useless things than to know nothing.

---Seneca

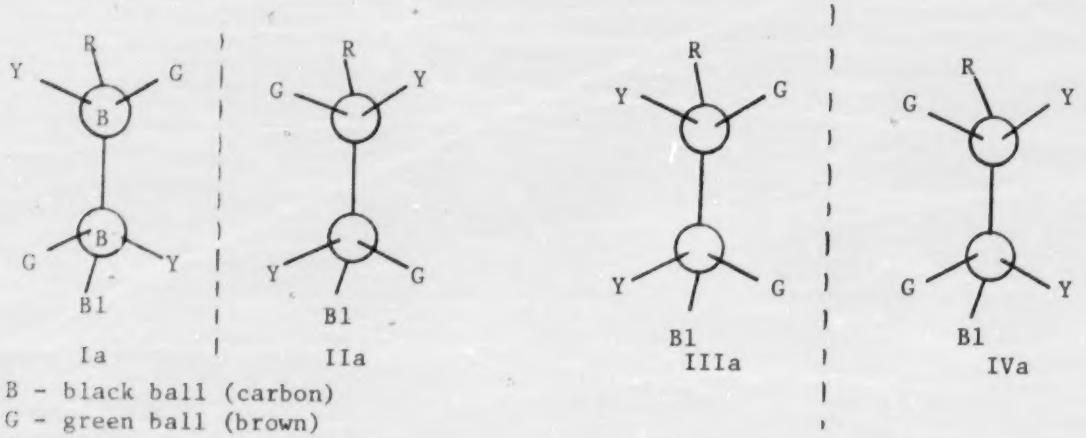
STEREOISOMERISM II

DIASTEREOISOMERISM

Example No. 1 - Stereoisomers of 2,3-dibromopentane



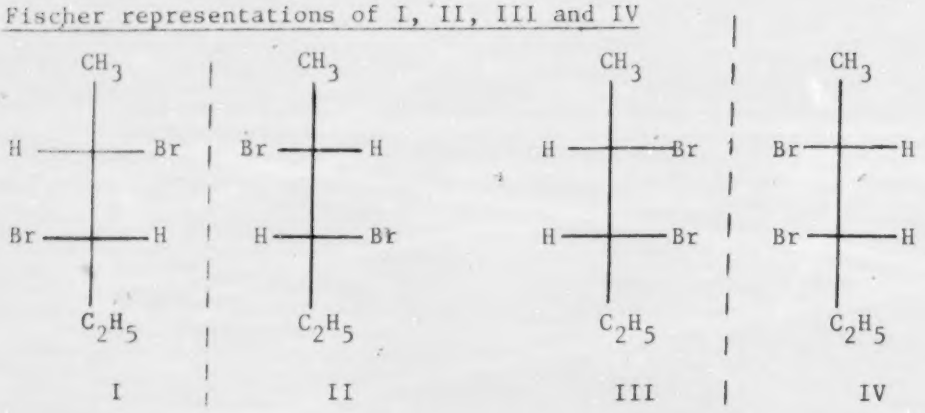
Analogous models to be made:



B - black ball (carbon)
G - green ball (brown)
Y - yellow ball (hydrogen)
Bl- blue ball (C_2H_5 group)
R - red ball (CH_3 group)

SIP No. 6
Tape II - Work Sheet

Fischer representations of I, II, III and IV



enantiomeric pair

enantiomeric pair

Are I and II superimposable? _____

Are I and II mirror image isomers? _____

I and II relative to each other are _____

Are III and IV superimposable? _____

Are III and IV mirror image isomers? _____

III and IV relative to each other are _____

Are I and III superimposable? _____

Are I and III mirror image isomers? _____

Are I and III stereoisomers? _____

I and III relative to each other are _____

Are I and IV superimposable? _____

Are I and IV mirror image isomers? _____

Are I and IV stereoisomers? _____

I and IV relative to each other are _____

Are II and III superimposable? _____

Are II and III mirror image isomers? _____

SIP No. 6
Tape II - Work Sheet

Are II and III stereoisomers? _____

II and III relative to each other are _____

Are II and IV superimposable? _____

Are II and IV mirror image isomers? _____

Are II and IV stereoisomers. _____

II and IV relative to each other are _____

DIASTEREOISOMERS are nonsuperimposable stereoisomers that are not mirror images of each other.

STEREOISOMERIC RELATIONSHIP OF - I, II, III, and IV

	I	II	III	IV
I	_____	enantiomer	diastereoisomer	diastereoisomer
II	enantiomer	_____	diastereoisomer	diastereoisomer
III	diastereoisomer	diastereoisomer	_____	enantiomer
IV	diastereoisomer	diastereoisomer	enantiomer	_____

Assignment No. 1

Draw stereochemical formulas for all the possible stereoisomers of 1-bromo-2,3-dimethyl pentane. Tabulate their stereoisomeric relationship in a table analogous to the one used in Example No. 1. Identify the ones which will be optically active when separated.

SIP No. 6
Tape II - Work Sheet

Assignment No. 2

Using Fischer representations, draw the configurations of all the stereoisomers of 2,3,4-tribromo hexane. Tabulate their stereoisomeric relationship in a table analogous to the one given in Example No. 1.

SIP No. 6
Tape II - Work Sheet

Assignment No. 3

a) The number of chiral centers in 2,3-dibromopentane (Example No. 1) is _____.

The number of possible stereoisomers of 2,3-dibromopentane (Example No. 1) is _____.

b) The number of chiral centers in 1-bromo-2,3-dimethylpentane (Assignment No. 1) is _____.

The number of possible stereoisomers of 1-bromo-2,3-dimethylpentane (Assignment No. 1) is _____.

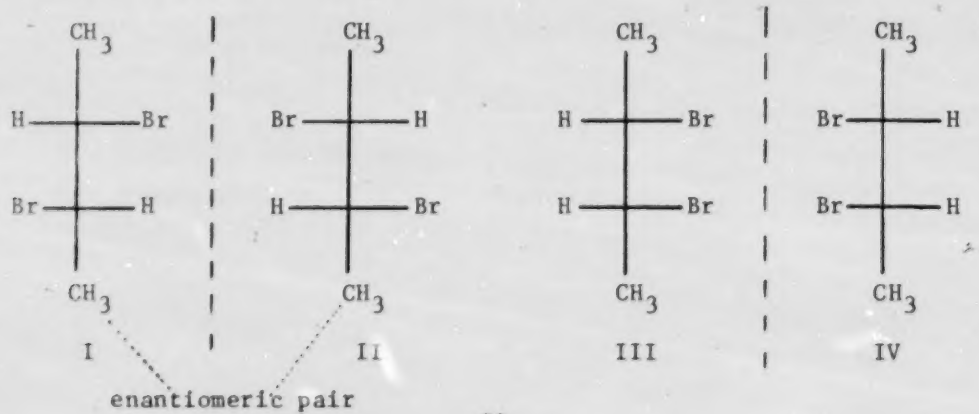
c) The number of chiral centers in 2,3,4-tribromohexane (Assignment No. 2) is _____.

The number of possible stereoisomers of 2,3,4-tribromohexane (Assignment No. 2) is _____.

If the number of chiral centers in a molecule was 4, the maximum number of possible stereoisomers would be 16.

What is the relationship between the numbers of the chiral centers in a molecule and the number of possible stereoisomers?

Example No. 2 - Stereoisomers of 2,3-dibromobutane



SIP No. 6
Tape II - Work Sheet

Are I and II superimposable? _____

Are I and II mirror image isomers? _____

I and II relative to each other are _____

Are III and IV superimposable? _____

Are III and IV mirror image isomers? _____

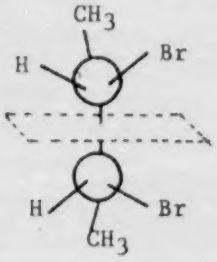
III and IV relative to each other are _____

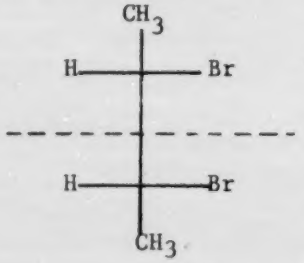
I and III relative to each other are _____

II and III relative to each other are _____

A MESO compound is one whose molecules are superimposable on their mirror images even though they contain chiral centers.

III = IV = optically inactive MESO compound





plane of symmetry

Stereoisomeric relationship of I, II, and III.

	I	II	III
I	_____	enantiomer	diastereoisomer
II	enantiomer	_____	diastereoisomer
III	diastereoisomer	diastereoisomer	_____

SIP No. 6
Tape II - Work Sheet

Assignment No. 4

Draw the stereochemical formulas for all the possible stereoisomers of the following compounds. Label pairs of enantiomers and meso compounds. Tell which isomers, if separated from all other stereoisomers, will be optically active.

a) 3,4-dimethyl hexane

b) 1,2,3,4-tetrachlorobutane

c) 2,3-dimethyl pentane

d) 2-iodo-3-bromo butane

SIP No. 6
Tape II - Work Sheet

Assignment No. 5

a) In a study of chlorination of butane, seven products of formula $C_4H_8Cl_2$ were isolated. What are their structures?

b) Three of them can be resolved into two enantiomers. Which ones are these? Draw the stereochemical formulas of these six enantiomers.

Assignment No. 6

State the difference between a meso compound and racemic mixture. What is the feature that they have in common?

SIP No. 6
Tape II - Work Sheet

Example No. 3

The stereoisomers from Example No. 1 have the following configurations:

I is: S, S-2,3-dibromopentane (or 2S, 3s ----

II is: R, R-2,3-dibromopentane (or 2R, 3R ----

III is: S, R-2,3-dibromopentane (or 2S, 3R ----

IV is: R, S-2,3-dibromopentane (or 2R, 3S ----

The stereoisomers from Example No. 2 have the following configurations:

I is: R, R-2,3-dibromobutane

II is: S, S-2,3-dibromobutane

III is: R, S- or S, R-2,3-dibromobutane

Assignment No. 7

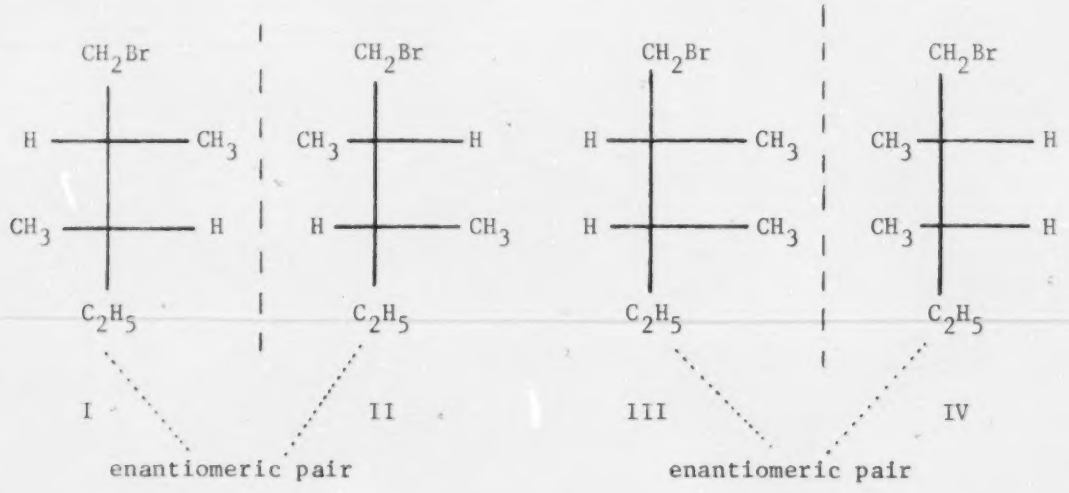
Assign the R/S specification to the stereoisomers in Assignment No. 1 and Assignment No. 4, Part b.

Self Instructional Package No. 6
Tape II - Answer Sheet

STEREOISOMERISM I

Diastereoisomerism

Assignment No. 1 - Stereochemical forms of 1-bromo-2,3-dimethyl pentane

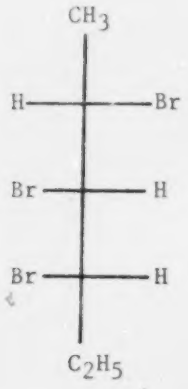


	I	II	III	IV
I	———	enantiomer	diastereoisomer	diastereoisomer
II	enantiomer	———	diastereoisomer	diastereoisomer
III	diastereoisomer	diastereoisomer	———	enantiomer
IV	diastereoisomer	diastereoisomer	enantiomer	———

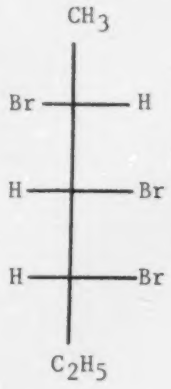
All of them (I, II, III and IV) will be opticall active when separated.

SIP No. 6
Tape II - Answer Sheet

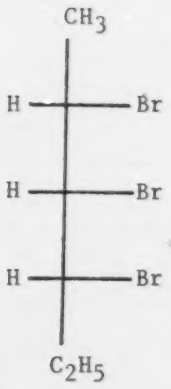
Assignment No. 2



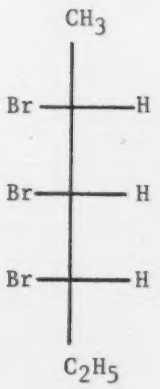
I



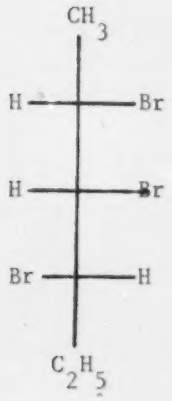
II



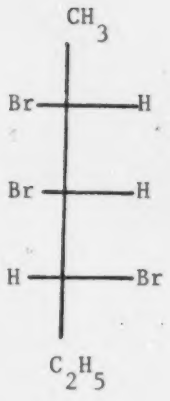
VII



VIII

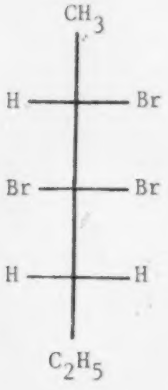


III

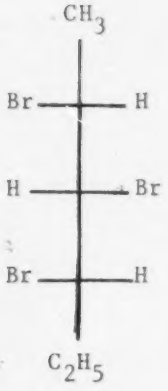


IV

SIP No. 6
Tape II - Answer Sheet



V



VI

	I	II	III	IV	V	VI	VII	VIII
I	___	E	D	D	D	D	D	D
II	E	___	D	D	D	D	D	D
III	D	D	___	E	D	D	D	D
IV	D	D	E	___	D	D	D	D
V	D	D	D	D	___	E	D	D
VI	D	D	D	D	E	___	D	D
VII	D	D	D	D	D	D	___	E
VIII	D	D	D	D	D	D	E	___

E = enantiomer

D = diastereoisomer

SIP No. 6
Tape II - Answer Sheet

Assignment No. 3

	No. of chiral centers	Max. No. of possible stereoisomers
a)	2	4
b)	2	4
c)	3	8
	4	16

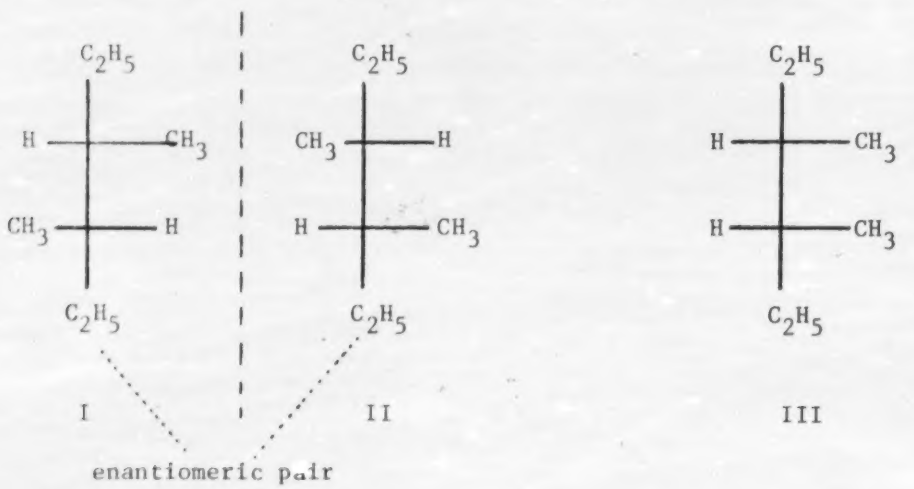
The max. No. of stereoisomers for a given molecule is:

$$n$$

(n = No. of chiral centers)

Assignment No. 4

a) 3,4-dimethyl hexane



enantiomeric pair

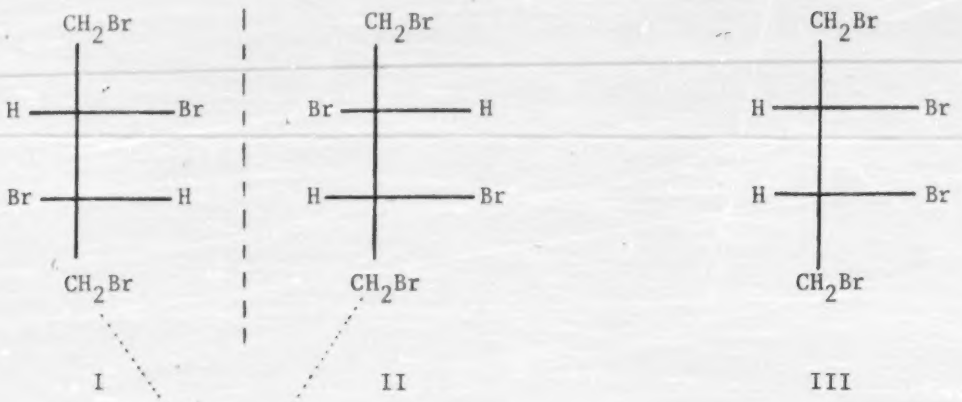
(optically active when separated)

Meso compound

SIP No. 6
Tape II - Answer Sheet

Assignment No. 4 (continued)

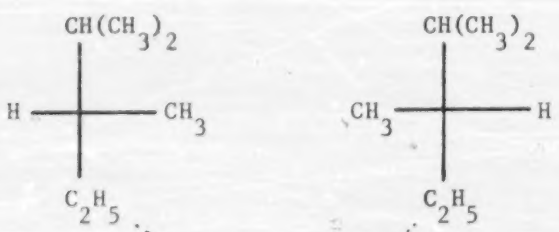
b) 1,2,3,4-tetrachlorobutane



(optically active when separated)
Enantiomeric pair

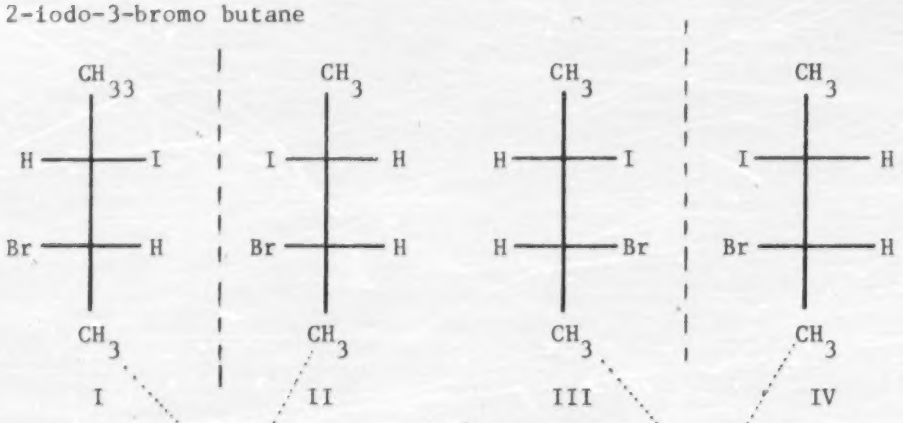
Meso compound

c) 2,3-dimethyl pentane



enantiomeric pair (optically active when separated)

d) 2-iodo-3-bromo butane



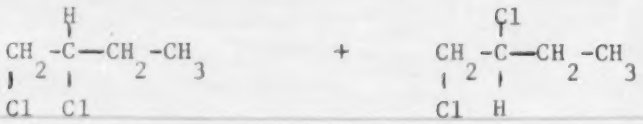
enantiomeric pair

enantiomeric pair

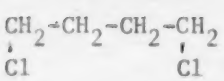
SIP No. 6
Tape II - Answer Sheet

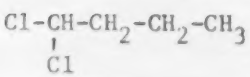
Assignment No. 5

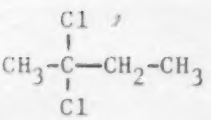
a)

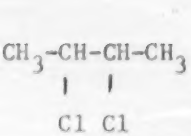
(1) 

(2)

(3)  (no chiral centers)

(4)  (no chiral centers)

(5)  (no chiral centers)

(6)  (meso compound)

(7)

SIP No. 6
Tape II - Answer Sheet

Assignment No. 6

Both MESO compound and Racemic mixture are optically inactive.

MESO compound is one single compound which cannot be further separated or resolved.

Racemic mixture is a MIXTURE of two enantiomers and can be further resolved into these constituents.

Assignment No. 7

Stereochemical formulas from the Assignment No. 1:

I R, S - 2,3-dimethyl pentane

II S, R- 2,3-dimethyl pentane

III R, R- 2,3-dimethyl pentane

IV S, S- 2,3-dimethyl pentane

Stereochemical formulas from the Assignment No. 4 (c)

I S, S- 1,2,3,4-tetrabromobutane

II R,R- 1,2,3,4-tetrabromobutane

III R,S or S,R 1,2,3,4-tetrabromobutane

Self Instructional Package No. 6
Form D - Progress Check Evaluation

STEREOSIOMERS I

Identify the statements below as True or False by placing a capital T or F in the space to the left.

1. _____ Racemic mixture is a mixture of two enantiomers.

2. _____ A (±) mixture is optically inactive.

3. _____ Resolution is separation of racemic mixture.

4. _____ The correct definition for enantiomers is: enantiomers are non-superimposable stereoisomers.

5. _____ An R configuration also indicates that it is a dextrorotatory substance.

6. _____ An optically active molecule is always a chiral molecule.

7. _____ A chiral molecule is always optically active.

8. _____ Diastereoisomers are not mirror image isomers.

9. _____ The correct definition for diastereoisomers is: diastereoisomers are nonsuperimposable stereoisomers.

10. _____ A meso compound possesses two chiral centers and consequently is optically active.

Circle the appropriate answer or answers in the following questions:

11. A prefix (-) indicates the following:

    a) That a molecule possesses S configuration.

    b) That a molecule is levorotatory.

    c) That a molecule possesses R configuration.

    d) That a molecule turns the plane-polarized light to the right.

12. The correct statements about enantiomers are:

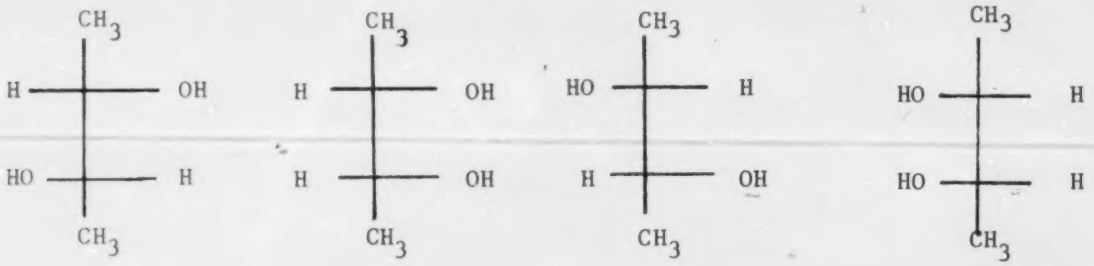
    a) They are nonsuperimposable mirror image isomers.

    b) They are optically active when separated.

    c) They have identical physical properties (B.P, M.P, D, etc.)

    d) When mixed together they are optically inactive.

The following three questions are related to the configurations below.
The correct statements about these configurations are:



13. a) I and II are diastereoisomers relative to each other.

    b) II and III are diastereoisomers relative to each other.

    c) III and IV are diastereosiomers relative to each other.

    d) II and IV are diastereoisomers relative to each other.

14. a) I and II are enantiomers relative to each other.

    b) I and III are enantiomers relative to each other.

    c) III and IV are enantiomers relative to each other.

    d) II and IV are enantiomers relative to each other.

15. a) I would exhibit optical activity.

b) II would exhibit optical activity.

c) III would exhibit optical activity.

d) IV would exhibit optical activity.

16. In 1,3-dibromobutane the chiral centers are:

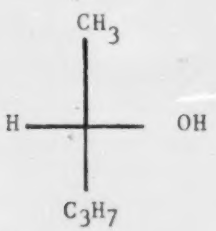
a) Carbon No. 1

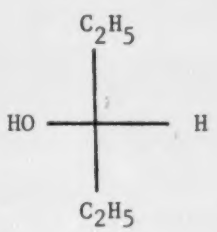
b) Carbon No. 2

c) Carbon No. 3

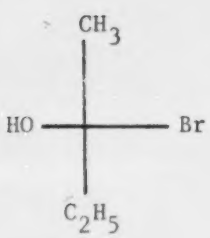
d) Carbon No. 4

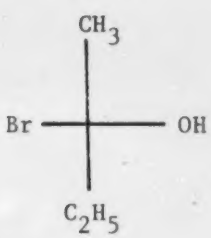
17. Identify the pairs of compounds in the following questions as: a) enantiomers, b) meso compound, c) diastereoisomers, d) structural isomers.





18.





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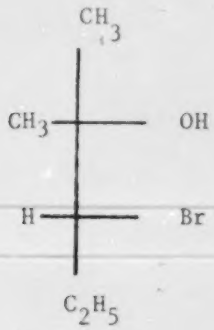
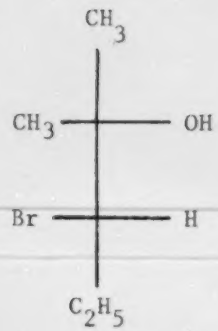
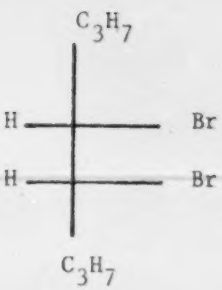
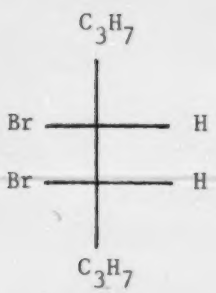

CH3
CH3
OH
H
Br
C2H5

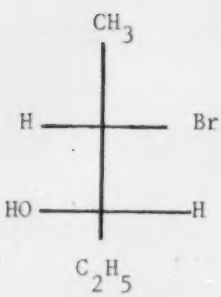

CH3
CH3
OH
Br
H
C2H5

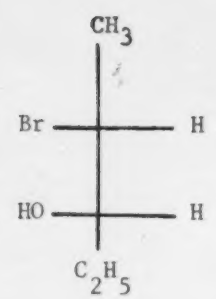
20.


C3H7
H
Br
H
Br
C3H7

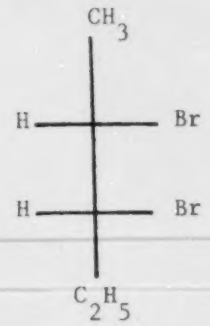

C3H7
Br
H
Br
H
C3H7

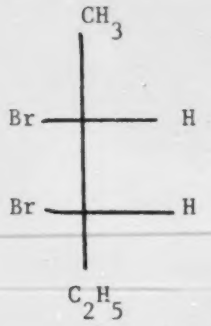
21.


CH3
H
Br
HO
H
C2H5


CH3
Br
H
HO
H
C2H5

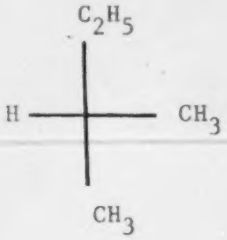
22.



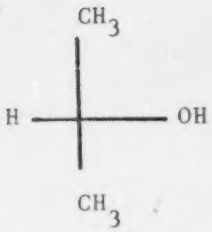


Identify the compounds in the next questions as: a) optically active, b) optically inactive, c) meso compound, d) enantiomer.

23.



24.



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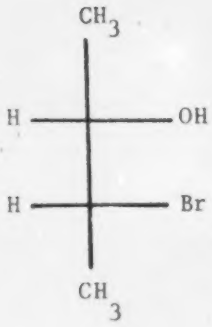
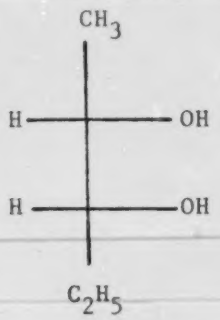
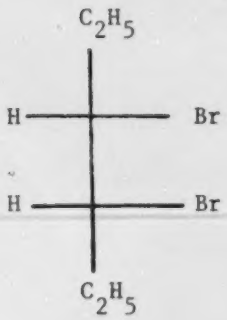


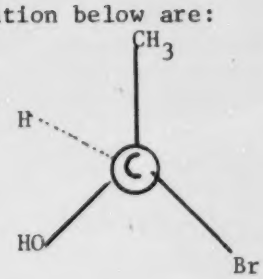
26.



27.



28. The correct statements about the configuration below are:



a) It is an R configuration.

b) It is an S configuration.

c) It is a dextrorotatory substance.

d) It is a levorotatory substance.

Self Instructional Package No. 6
Form B1- Self Evaluation Exercise - Answers

STEREOISOMERS I

1.	F	11.	c	20.	b
2.	F	12.	b, d	21.	a, d
3.	F	13.	a, b, c	22.	b
4.	T	14.	a, b, d	23.	a, d
5.	T	15.	a	24.	b, c
6.	T	16.	d	25.	b
7.	F	17.	b	26.	b, d
8.	F	18.	c	27.	a, b, d
9.	T	19.	a	28.	a
10.	T				

Self Instructional Package No. 6
Form D1 - Progress Check Evaluation - Answer Sheet

STEREOISOMERS I

1. F
2. T
3. T
4. F
5. F
6. T
7. F
8. T
9. T
10. F
11. b
12. a, b, c
13. a, b, c
14. b
15. a, c
16. c
17. d
18. a
19. a
20. b
21. c
22. a
23. b
24. b
25. a, d
26. a, d
27. b, c
28. a

STEREOCHEMISTRY - GLOSSARY

DEFINITIONS

1. STRUCTURAL ISOMERS - Compounds with the same molecular formula but different structure. They have different physical properties. (Consequently can be separated by employing simple laboratory techniques such as distillation and recrystallization.)

2. STEREOISOMERS - Compounds with the same molecular formula, the same structure but different arrangement of atoms in space.

3. CONFORMATIONAL ISOMERS - Stereoisomers which can be interconverted into each other due to the free rotation around the carbon - carbon single bond. They have the same physical properties. (Consequently cannot be separated.)

4. CHIRAL CENTER - A carbon atom to which four <u>different</u> groups are attached.

5. CHIRAL MOLECULES - Molecules that are not superimposable on their mirror images.

6. ENANTIOMERS - Are <u>nonsuperimposable</u> mirror image isomers. They have identical physical properties except for the sign of the angle of rotation α. (Consequently they cannot be separated by simple laboratory technique.)

7. DIASTEREOISOMERS - Stereoisomers that are not mirror images of each other. (They have different physical properties.)

8. RACEMIC MODIFICATION OR RACEMIC MIXTURE - A mixture made up of equal parts of enantiomers. It is optically inactive.

9. MESO COMPOUND - A compound that is optically inactive (superimposable on its mirror image) even though it contains chiral centers.

10. CONFIGURATION - It is the arrangement of atoms that characterizes a particular stereoisomer.

11. GEOMETRIC ISOMERS* - Diastereoisomers which exist due to the hindered rotation around the carbon - carbon double bond. (Z and E structures.)

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* - S.I.P. #7